INTERNATIONAL STANDARD

**ISO 16133**

First edition
2004-03-15

# Soil quality — Guidance on the establishment and maintenance of monitoring programmes

*Qualité du sol — Lignes directrices pour l'établissement et l'entretien de programmes de surveillance*

Reference number
ISO 16133:2004(E)

ISO copyright office
Case postale 56 • CH-1211 Geneva 20
Tel. + 41 22 749 01 11
Fax + 41 22 749 09 47
E-mail copyright@iso.org
Web www.iso.org

Published in Switzerland

# Contents

Page

**Foreword** ..... iv

**Introduction** ..... v

**1 Scope** ..... 1

**2 Terms and definitions** ..... 1

**3 Monitoring objectives** ..... 3
**3.1 General** ..... 3
**3.2 Examples of monitoring purposes** ..... 4

**4 Monitoring programme** ..... 4
**4.1 General considerations** ..... 4
**4.2 Elements of a monitoring programme** ..... 5
**4.2.1 Status of the monitoring sites** ..... 5
**4.2.2 Changes at the monitoring sites** ..... 5
**4.2.3 Interpretation of status and changes** ..... 6
**4.2.4 Selection of sites** ..... 6
**4.3 Sampling and measurement** ..... 7
**4.3.1 General** ..... 7
**4.3.2 Site design and identification** ..... 7
**4.3.3 Soil and site description** ..... 7
**4.3.4 Sampling** ..... 7
**4.3.5 Field and laboratory measurements** ..... 7
**4.3.6 Specimen banking** ..... 7
**4.3.7 Time interval between samplings** ..... 8

**5 Data quality and quantity** ..... 8

**Annex A** (informative) **Examples of monitoring programmes** ..... 9

**Bibliography** ..... 33

# Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of technical committees is to prepare International Standards. Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

ISO 16133 was prepared by Technical Committee ISO/TC 190, *Soil quality*, Subcommittee SC 7, *Soil and site assessment*.

# Introduction

Monitoring is the process of repetitive observation, for defined purposes, of one or more components of the environment according to pre-arranged schedules in space and time using comparable methods for environmental sensing and data collection (see reference [1] in the Bibliography). Monitoring schemes are used all over the world for a large number of purposes. Soil monitoring, particularly, is a long-term undertaking. The quality and the utility of the information from the monitoring is to a large degree determined by the choice of monitoring sites and by their maintenance over the years, and by appropriate quality control at all stages of the process.

Monitoring associated with industrial (contaminated) sites can involve many specific considerations, including legal requirements. The guidance in this International Standard is not designed or intended to cover such situations.

# Soil quality — Guidance on the establishment and maintenance of monitoring programmes

## 1 Scope

This International Standard gives general guidance on the selection of procedures for the establishment and maintenance of programmes for long-term monitoring of soil quality. It takes into account the large number of objectives for soil-monitoring programmes.

This International Standard is intended to help provide a basis for dialogue between parties which might be involved in a monitoring scheme. Examples of soil-monitoring programmes from several countries are provided in Annex A.

## 2 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

**2.1**
**accumulation**
increase of the concentration of a substance in soil due to substance input being larger than substance output

NOTE Adapted from ISO 11074-1:1996

**2.2**
**anthropogenic influence**
changes in soil properties caused by human activities

[ISO 11074-1:1996]

**2.3**
**background concentration**
**natural pedogeochemical content**
geogeneous or pedogeneous average concentration of a substance in an examined soil

[ISO 11074-1:1996]

**2.4**
**diffuse source input**
**non-point source input**
input of a substance emitted from moving sources, from sources with a large area or from many sources

NOTE 1 The sources can be cars, application of substances through agricultural practices, emissions from town or region, deposition of sediment through flooding of a river.

NOTE 2 Diffuse source input usually leads to sites that are relatively uniformly contaminated. At some sites, the input conditions may nevertheless cause a higher local input near the source or where atmospheric deposition/rain is increased.

[ISO 11074-1:1996]

**2.5**
**leaching**
movement of dissolved substances caused by the movement of water or other liquids in the soil

[ISO 11074-1:1996]

**2.6**
**locally contaminated site**
site with discrete areas of high concentrations of substances hazardous to soil

NOTE The extent of contamination is usually small and the gradient of concentration within the site is steep.

[ISO 11074-1:1996]

**2.7**
**monitoring**
process of repetitive observation, for defined purposes, of one or more elements of the environment according to pre-arranged schedules in space and time using comparable methods for environmental sensing and data collection

**2.8**
**monitoring site**
area in which investigations will take place

NOTE Areas which are relatively homogeneous are usually chosen.

**2.9**
**point-source input**
input of a substance from a stationary discrete source of definite size

NOTE 1 The sources can be stack emissions, accidental spills, waste dumps, spills on industrial sites, major leaks from sewers and other pipelines.

NOTE 2 Point-source input can cause both locally contaminated sites and relatively uniformly contaminated sites.

[ISO 11074-1:1996]

**2.10**
**risk assessment**
assessment of damaging effects of a polluted site on man and the environment with respect to their nature, extent and probability of occurrence

[ISO 11074-1:1996]

**2.11**
**sample**
portion of material selected from a large quantity of material

[ISO 11074-2:1998]

**2.12**
**sampling**
process of drawing or constituting a sample

[ISO 3534-1:1993]

NOTE For the purpose of soil investigation, “sampling” also relates to selection of locations for the purpose of *in situ* testing carried out in the field without removal of material.

[ISO 11074-2:1998]

**2.13**
**sampling point**
location within the monitoring site at which physical sampling takes place

**2.14**
**sampling procedure**
operational requirements and/or instructions relating to the use of a particular sampling plan

[ISO 11074-2:1998]

**2.15**
**soil damage**
alteration of soil properties which cause negative effects on one or more soil functions, human health or environment

[ISO 11074-1:1996]

**2.16**
**substance input**
movement of a substance from another environmental compartment into a soil

[ISO 11074-1:1996]

**2.17**
**substance output**
movement of a substance from the soil into another environmental compartment

[ISO 11074-1:1996]

**2.18**
**uniformly contaminated site**
site with a generally uniform concentration of a substance hazardous to soil

NOTE The extent of the contamination is usually large and the gradient of concentration within the site is rather shallow.

[ISO 11074-1:1996]

# 3 Monitoring objectives

## 3.1 General

Monitoring is an important tool for the early detection of environmental impact on soil and soil processes. It thus has a major role in the prevention or minimization of environmental damage or the detection of environmental improvement. By the early detection of environmental impact, or the potential for such impact, a monitoring programme could help to reduce or remove the costs of reaching or maintaining a given level of environmental management, protection or quality.

Monitoring programmes can also be used to evaluate the outcome of environmental policies, to assist in the development of strategies for soil protection and environment management. They can also serve as research

platforms for the development and validation of field and analytical methods and of models of soil and related environmental processes.

The range of purposes for which soil-monitoring programmes can be designed encompasses such a vast range of time scales, variables and processes that it is not possible to give specific guidance on the design of a monitoring programme to meet all the objectives which might be covered by this diversity. The selection of sites, sampling schemes, etc. should be made from a consideration of the specific objectives of the particular monitoring programme. This International Standard identifies the principles underlying such programmes.

### 3.2 Examples of monitoring purposes

The following list gives some examples of monitoring purposes:

— short-, intermediate- and long-term environmental impacts varying in magnitude, importance, duration and probability;

— changes in chemical, biological and physical soil properties (e.g. pH, adsorption processes, toxic element accumulation, radiation, compaction, erosion) and the dynamics of changes in such properties;

— effects of human impacts;

— differentiation of human impacts from inter-annual variability and longer-term climate change;

— differentiation of local contamination from long-range transport;

— evaluation of productivity;

— assessment of biological diversity;

— input of elements into the soil environment and output of elements from the soil environment;

— transport processes in the soil profile (gases; particles; elements or compounds in solution);

— calculations of elements uptake and retention by particular components of the ecosystem.

## 4 Monitoring programme

### 4.1 General considerations

It is generally not feasible to monitor all variables at all locations. Wherever possible, consideration should be given to the monitoring of soil properties which, as well as being of specific interest themselves, might also act as a surrogate for some property or process which is otherwise difficult, time consuming or expensive to measure directly. For example, soil pH and clay content (a potential surrogate for soil hydrological behaviour) might act as factors for ranking pollutant mobility. It will be important to establish what long-term records already exist at a site before identifying additional variables for monitoring and what degree of continuity of measurement is required into the future. The close reciprocal benefits of monitoring and research on specific scientific questions should be considered.

The final series of potential monitoring options should be ranked according to their value (scientific relevance; sensitivity to impacts; value as an index for changes in many other environmental variables that are not measured) and feasibility (financial, logistic, analytical, ease of interpretation). This prioritization should also be revised and updated at regular intervals. The costs of appropriate storage of samples and long-term quality assurance, e.g. cross-checking when improvements in analytical techniques are made, should not be underestimated.

Identification of habitat types is a key element of the monitoring plan, and is also a logical starting point for the development of an environmental monitoring strategy. It is also necessary to consider the number of sites that might be required to give appropriate spatial and temporal cover for the monitoring, and whether the site density is appropriate for all variables. It is usually impractical to establish sites that cover all combinations of soil and habitat. Consideration needs to be given, for example, to combinations that are most common or most sensitive to a given impact. It should be remembered that other research, into e.g. water quality or biodiversity, might be possible on the same site, thus adding to its value.

Some other factors that have to be considered are the following:

— partners and organizations involved, and an assessment of their objectives and long-term commitment;

— existing guides and protocols, and the degree to which they satisfy the objectives of the programme;

— ownership of sites, and likely long-term commitment of the site or sites to a monitoring programme;

— availability of sites;

— effects of future changes in land use (if this is an important factor), or the landscape in the vicinity of the site(s) since changes might affect the usefulness of the site in the long term;

— the funding of the programme, and its long-term security;

— quality assurance, including documentation (see below);

— data management, accessibility of the data, intellectual property and issues of confidentiality and rights to publish.

It is very strongly recommended that all parties to a long-term monitoring programme agree to the objectives, funding, mutual responsibilities and other relevant issues before a monitoring programme begins, and that they enter into a formal agreement which defines each party's role in the programme, including financial and legal constraints.

## 4.2 Elements of a monitoring programme

### 4.2.1 Status of the monitoring sites

The history of all sites, which might be considered, should be documented. This is an essential part of any assessment of representativeness, and ensures that the chances of the unexpected, which might jeopardize the usefulness of the site, are minimized. Such assessment can involve the characterizing of present-day soil properties at representative sites. Issues such as ownership, access, etc. (see 4.1) can usually be resolved at this stage. Information about other monitoring programmes forms part of this preliminary investigation.

### 4.2.2 Changes at the monitoring sites

The purpose of measuring change in soil properties should be clear from the start. It may also be useful to invert the question and ask what changes could be measured using such a particular site or programme design, even if all the properties might not be required at the start. Sites which allow expansion of activity for future needs can have advantages over more limited sites. It might be that one purpose of the programme is to establish changes in soil properties (e.g. pH, humus content, levels of toxic substances, water permeability, microbiological activity) and the dynamics of changes in such properties over shorter rather than longer time scales. This has large implications for the amount of soil sampling, and thus site disturbance, which the site might have to accommodate without having its functions seriously affected. The possibility of investigating other environmental compartments can make one site a more attractive proposition than another, especially if it interests a larger group of researchers, funders, etc.

#### 4.2.3 Interpretation of status and changes

The data on status and changes may be used to interpret the following:

— reference/background properties;

— degradation/improvement of one or more soil characteristics and functions (and the effect of this on other soil or site properties);

— short-term and long-term environmental impact and bioavailability of extraneous inputs, applied wastes, atmospheric or water-borne substances or off-site management;

— ecological functions of soils;

— productivity functions of soils;

— influence on other environmental compartments, or of these on the soils at the site.

#### 4.2.4 Selection of sites

The sites should be selected so that they are suitable for the objectives of the programme with respect to geology, soil type, vegetation and land use, topography, climate and ecological habitat. Other important criteria are anthropogenic impact and natural background conditions (e.g. trace element levels, acidity, salinity, buffer capacity).

The choice of geographical distribution of monitoring sites is often influenced by the degree of pre-existing knowledge of the landscape or soil pattern. Where relatively little is known, statistical approaches are often the most appropriate, although this can imply considerable preliminary investigation to establish the variability of the area in question. In general, there are four main choices in the selection of geographical distribution. They are listed below without priority.

— **Regular grid.** The sites are selected using a regular grid. In order to provide representative data, this approach generally requires a large number of sites. The interval between the grid points is very dependent on the size of the area of interest, as well as the degree of change being measured in the property. The smaller the change to be measured in a property, the larger the number of sites required in a given area.

— **Statistical approach.** The sites are selected by using (geo)statistically produced patterns, designed to minimize the required number of sites. However, this implies considerable preliminary investigation, as geostatistical investigations have, as their central aim, the establishment of a reliable variogram for a given property. If the different properties have different degrees of spatial dependence, as they often do in soils, then the number of sites needed to establish this can be as large as that for the regular grid.

— **Hypothesis-oriented approach**. The monitoring options are evaluated on the basis of their ability to detect and quantify impacts hypothesized to result from specific human activities. The sensitivity, spatial extent and frequency of monitoring have to be appropriate to detect the hypothesized impacts. This can also involve considerable preliminary investigation.

— **Typological approach**. This is based on a stratification of soils according to land use and/or soil type, or soil horizon, on soil parent material, or soil extent, or distance from potential contamination sources, etc.

In order to make efficient use of available resources, it is always important to consider the possibilities to integrate the sites with other monitoring programmes. Examples of selection of monitoring sites are given in Annex A. Both synergistic and disturbing effects (e.g. caused by sampling activities or experimental treatments) should be considered if sites are to be used for different monitoring programmes.

## 4.3 Sampling and measurement

### 4.3.1 General

A sampling and measurement plan is an important part of a monitoring programme. Such a plan should include procedures in the following areas.

### 4.3.2 Site design and identification

The chosen site(s) should allow the range of measurements appropriate for the objectives of the soil-monitoring programme, and any other monitoring activities which add value to this programme. The layout of the site should allow repeated representative sampling, without compromising the overall functioning of the site or the soils within it. The site should be protected from unwanted external disturbances.

The choice of sampling points within the monitoring site depends on several factors. The sampling point might have to allow for the digging of soil-profile pits, the installation of soil instruments, repeated sampling by augers, possibly the introduction of designed experiments, e.g. to test the effect of different cropping regimes on the properties monitored, and so on. These factors shall be estimated at the preliminary stage, and the site design modified to include them. If none of these larger factors needs to be allowed for, the sampling point may be located at the centroid of the monitoring site.

### 4.3.3 Soil and site description

Soil and site description should be performed in accordance with ISO 15903 and ISO 11259.

### 4.3.4 Sampling

Sampling includes for example the sampling strategy, sampling techniques, labelling, transport and storage. Whenever possible International Standards should be used, see Bibliography. Careful thought should be given to sampling schemes so as to cause minimum disturbance to the site and its properties. Some examples covering the principles of the design and implementation of soil monitoring programmes are given in Annex A.

### 4.3.5 Field and laboratory measurements

Field and laboratory measurements should be selected according to the objectives.

It is strongly recommended that the following minimum data set of chemical and physical parameters be included, as many of these underpin the interpretation of soil data in the wider context: pH, organic carbon content, cation exchange capacity, electrical conductivity, dry matter content, particle size distribution and bulk density. There is no recommended minimum data set for biological parameters, as the choice depends on the objectives. Standardized methods should be used wherever possible.

The relevant International Standards for the recommended minimum data set are given in the Bibliography.

Examples of selection of parameters in relation to the purpose of the monitoring objectives are given in Annex A.

### 4.3.6 Specimen banking

A specified portion of each sample should be stored for future needs as appropriate. Sufficient sample should be taken so as to allow re-analysis of many of the properties for an extended period into the future. A specimen bank also makes it possible to include new forms of analysis in the monitoring programme at a later date.

It should be considered at the outset whether special storage conditions, e.g. temperature or humidity, have to be maintained in order to guarantee that important parameters will remain stable over time. In some cases

samples should be stored frozen, rather than dried. If determinations of some parameters have to be postponed, for financial or other reasons, and long-time parameter stability cannot be guaranteed, efforts should be made to determine these parameters at the earliest possible occasion.

Contamination from sample containers should be minimized by careful choice of storage media.

The costs of specimen banking over many years can be considerable. The amount of space required to store samples in the long term can be considerable if many samples are involved, whether they are from separate sites, or numerous locations within one site, or both.

#### 4.3.7 Time interval between samplings

The planned time interval depends on the objectives and parameters (e.g. spatial variability, dynamics, and expected changes). It should be taken into account that time intervals may have to be changed because of unexpected events, and almost certainly will differ with different variables.

## 5 Data quality and quantity

The quality of the data obtained can be assured by

— proper training of all staff, not only of those involved at the start of the project, but also of those who replace them over time. It is strongly recommended to keep a record of the training given,

— setting formal data quality objectives (e.g. for accuracy, reproducibility, etc.),

— using sampling procedures based on guidance in International Standards,

— using standardized analytical and test methods such as those listed in the Bibliography or, where International Standard methods are not available, those published by national standardization organizations or official bodies,

— using laboratories which apply methods accredited under ISO 17025[32],

— using laboratories that take part in relevant proficiency testing schemes,

— using commissioning agents who employ their own quality assurance procedures,

— adherence to agreed protocols,

— the keeping of proper records at all stages of the monitoring programme, ensuring that these records remain readable and unambiguous, and keeping such records in an accessible place.

As monitoring is a long-term undertaking, it may be impossible to avoid changes in methodology and/or use of different laboratories. It is very important to keep a record of such changes and to calculate the correlation between parameter values before and after the changes. For coding of data, a codification key should be defined. Comparability of these data with international systems of soil information should be considered.

The amount of data generated from monitoring programmes may be considerable. It is strongly recommended to estimate the quantity of data at the outset, and to make an appropriate plan for data storage. If not well planned, this can present a formidable logistical problem when sampling programmes run for decades.

Commonly used database systems should be employed. It is good practice to appoint a person or a unit in the organization to be responsible for the security of the database and for handling back-up procedures.

# Annex A
(informative)

# Examples of monitoring programmes

## A.1 Introduction

This annex contains short presentations, in tabular form, of different regional and national monitoring programmes. The examples provide the reader with a general understanding of the objectives of the programmes and how they have been set up to reach the objectives.

## A.2 Examples

### A.2.1 The agricultural environmental monitoring programme in Norway (JOVA)

| | |
|---|---|
| Title | The agricultural environmental monitoring programme in Norway (JOVA) |
| Level | National |
| Area of activity | Soil erosion, nutrient loss, pesticides and heavy metals. |
| Context | The Norwegian Ministry of Agriculture initiated the programme in cooperation with the Ministry of Environment in 1992. It is a nationwide programme. Initially it focussed on monitoring of erosion and nutrient losses from agricultural soils, but in 1995 the programme was extended to include pesticides and heavy metals.<br>The programme is based on monitoring of small agricultural catchments, representing major cropping systems under varying soil and climatic conditions. |
| Monitoring objectives | The primary objectives of the programme are<br>— to give the public administration in Norway a basis for implementing a cost-effective environmental policy,<br>— to document the result of environmental efforts within agriculture as compared to the Ministerial Convention of the North Sea,<br>— to inform the agricultural sector about the environmental impact of agricultural practices and the result of environmental efforts. |
| Number of sites | In the year 2000 the programme covered 13 catchments in different parts of Norway. The first two were established in 1985, the rest in 1990 or later.<br>Catchment size varies between 65 and 2 000 ha, with 35 % to 60 % of the main land use being agriculture. Livestock density varies, and up to 54 % of a catchment area may be forested. |
| Criteria for site selection | Sites for monitoring nutrients and erosion are chosen to represent different soils, agricultural practices and climates in Norway. Priority is given to sites with as few point-sources as possible. Agriculture is aimed to be the dominant source of pollution. The sites for pesticide analysis are chosen from areas with high frequency of pesticide use. |

| | |
|---|---|
| Sampling plan | Soil and nutrient losses, pesticides and heavy metals are measured at catchment monitoring stations. Eleven monitoring stations continuously record water discharge, and volume-proportional water samples are collected automatically. These monitoring stations are directly linked to the main office, enabling automatic data retrieval. The two remaining monitoring stations sample point samples only for pesticide analysis. |
| Field observations | Soil types in the catchments are mapped according to a standardized method and classified according to the Canadian System of Soil Classification (CSSC) and the World Reference Base for Soil Resources (WRB).<br><br>Continuous discharge measurements are carried out using a V-notch or a Crump weir in combination with a Campbell data logger. Water samples are taken on a volume-proportional basis. The average yearly temperature, and for some stations precipitation, is measured.<br><br>Although the catchments are usually less than 700 ha in size, additional measurements for two catchments are carried out for a field in connection to the main catchment. This enables researchers to obtain information about retention and transformation processes in agricultural areas.<br><br>Farm practices, such as soil tillage, fertilizer and manure application, crop type and crop yields, are recorded annually in each catchment. This is of particular importance, as one of the main goals of the programme is to relate losses of plant nutrients to catchment characteristics and changes in agricultural practices. |
| Laboratory measurements | Soil samples from 7 to 15 randomly selected fields in 6 of the catchments were analysed for texture, P-AL, total nitrogen, and ignition loss. For these fields, mineral nitrogen is analysed twice a year.<br><br>Water samples are regularly analysed for content of total nitrogen, nitrate, total phosphorus, phosphate, suspended solids and pH.<br><br>Analyses of pH, suspended solids and total phosphorus are carried out using Norwegian standard methods, while *de facto* standards based on international methods are used for the analysis of phosphate-phosphorus, nitrate-nitrogen and total nitrogen. |
| Soil archive | Results from the programme are stored in a database at Jordforsk.<br><br>Soil and water samples are not stored. |
| Contact address | Jordforsk — the Norwegian Centre for Soil and Environmental Research<br>Frederik A. Dahls vei 20<br>N-1432 Aas<br>Norway<br><br>http://www.jordforsk.no/jovabase/frame.htm |

### A.2.2 Environmental Change Network (United Kingdom)

| | |
|---|---|
| Title | Environmental Change Network |
| Level | UK |
| Area of activity | Soil |
| Context | The UK decided at the beginning of the 1990s that a programme was needed to assess the long-term change in soil properties at the national scale. This resulted in the establishment of the Environmental Change Network (ECN) |
| Monitoring objectives | The objectives of the network are<br>— to establish and maintain a selected set of sites within the UK from which to obtain comparable long-term data sets by means of measurements at regular intervals of variables identified as being of major environmental importance,<br>— to provide for the integration and analysis of these data sets, so as to identify environmental changes, and to improve understanding of the causes of change,<br>— to make these long-term data sets available as a basis for research and prediction,<br>— to provide, for research purposes, a range of representative sites where there is good instrumentation and reliable environmental information. |
| Number of sites | 13 |
| Criteria for site selection | The sites were chosen at experimental stations largely under the control of governmental and quasi-governmental organizations, in order to ensure that long-term continuity of measurement was likely to remain possible. The sites are representative of a wide range of soil types and habitats, from mountain bog to lowland agriculture. |
| Sampling plan | The sites are first surveyed to establish the homogeneity of the site with respect to soil type, and an area of 300 m × 300 m with least variation is selected. Within that area, a 1 ha plot is laid out for the soil-monitoring activity. This area is divided into numbered cells according to a strict protocol. Five-yearly sampling is carried out in each of 16 numbered 5 m × 5 m cells in each of six blocks. Each 5 m × 5 m cell is subdivided into 25 numbered subcells of 1 m × 1 m. On each sampling occasion, only one subcell is randomly selected from each 5 m × 5 m cell, giving a total of 16 sampling sites for each block at each five-yearly sampling. At the next five-yearly sub-sampling, a different set of 1 m × 1 m sub-cells is used. Two sets of soil samples will be taken to a maximum depth of 30 cm from each sampled sub-cell. One set is based on depths 0 cm to 5 cm, 5 cm to 10 cm, 10 cm to 20 cm, and 20 cm to 30 cm. The other set corresponds to horizons within the top 30 cm. Twenty-year samples are taken from soil profiles. These require excavation of the ground to expose a vertical section of soil suitable for description, and will be from six pits, each located in a 5 m × 5 m cell chosen at random from each block. Samples are collected from each soil horizon recognized in the description to about 1 m depth (or less if rock is encountered) and by standard depths of 0 cm to 5 cm, 5 cm to 10 cm, 10 cm to 20 cm, 20 cm to 40 cm, 40 cm to 60 cm, 60 cm to 80 cm, 80 cm to 100 cm, and 100 cm to 120 cm. In addition, triplicate core samples are taken from each horizon for the measurement of soil water release characteristics and bulk density. |
| Field observations | The soils are characterized at each ECN site and for each of the target sampling areas of 1 ha. A soil survey map is produced. Each soil-profile pit is described according to UK national schemes. |

| | |
|---|---|
| Laboratory measurements | These are as follows:<br>Each bulked horizon and depth band sample from the five-yearly core samples and each horizon and depth band from the 20-yearly profile samples is analysed for<br>— moisture on soil < 2 mm oven-dried overnight at 105 °C,<br>— pH on field-moist and air-dry samples, on 1:2,5 extracts in water and 0,01 mol/l calcium chloride,<br>— exchangeable acidity, sodium, potassium, calcium, magnesium, aluminium,<br>— total nitrogen, phosphorus, sulfur, organic carbon, inorganic carbonate,<br>— aqua regia-extractable lead, zinc, cadmium, copper, cobalt, molybdenum, chromium, nickel,<br>— total mercury and arsenic,<br>— extractable iron, aluminium, phosphorus,<br>— dry soil bulk density and water-release characteristics are determined in triplicate for each soil horizon at 20-year intervals. |
| Soil archive | Air-dried samples (minimum 1 kg) of each and every soil layer sampled are stored in an archive. |
| Contact address | Centre for Ecology and Hydrology<br>Lancaster Environment Centre<br>Library Avenue<br>Bailrigg<br>Lancaster LA1 4AP<br>http://www.ecn.ac.uk/ |

### A.2.3 Integrated National Programme for Forest Ecosystems Control, CONECOFOR (Italy)

| | |
|---|---|
| Title | Integrated National Programme for Forest Ecosystems Control (CONECOFOR) |
| Level | National |
| Area of activity | Air pollution |
| Context | In the framework of the International Cooperative Programme on Assessment and Monitoring of Air Pollution Effects on Forests and of the International Cooperative Programme on Integrated Monitoring of Air Pollution Effects on Ecosystems. |
| Monitoring objectives | To study atmospheric pollution, soil acidification trends and climate change effects on Italian forest ecosystems |
| Number of sites | National network consisting of 27 permanent forest sites |
| Criteria for site selection | The sites should represent Italian main biocenosis.<br>The sites should meet the national criteria of regional and national representativeness; ecological and biocenotic homogeneity of the sites and their buffer zones; accessability; distance from known local air-pollution sources; land ownership; protection regime; availability of local support personnel. |
| Sampling plan | Starting year: 1995; number of active areas: 20; Soil sampling frequency: 10 years. Every site consists of two separate but adjacent, 2 500 $m^2$ area plots (blank and monitoring), surrounded by a buffer zone, varying from 10 ha to 100 ha. Soil samples are collected from the monitoring plot.<br>According to the mandate, two monitoring and sampling levels were decided for the depth of sampling and parameters to be determined.<br>Level I includes: Organic layer, mineral layer 0 cm to 10 cm, mineral layer 10 cm to 20 cm;<br>Level II includes: Organic layer, mineral layer 0 cm to 10 cm, mineral layer 10 cm to 20 cm, mineral layer 20 cm to 40 cm. |
| Field observations | Soil profile descriptions and classification according to the FAO Classification. |
| Laboratory measurements | Parameters to be determined in the organic layer (mandatory): pH ($CaCl_2$); organic C; total N; $CaCO_3$ (if pH $>$ 5,5); total P, Ca, K, Mg, Mn by aqua regia; heavy metals Cu, Pb, Cd, Zn by aqua regia; amount of organic layer;<br>Parameters to be optionally determined in the organic layer: other metals: Al, Fe, Cr, Ni, S, Hg, Na by aqua regia; exchangeable acidity; BCE: Ca, Mg, K, Na; ACE: Al, $Fe^{3+}$, Mn, H; CEC, base saturation; pH ($H_2O$);<br>Parameters to be determined in the mineral layer 0 cm to 10 cm (mandatory): pH ($CaCl_2$); organic C; total N; $CaCO_3$ (if pH $>$ 6); aqua regia heavy metals Cu, Pb, Cd, Zn; exchangeable acidity; BCE: Ca, Mg, K, Na; ACE: Al, $Fe^{3+}$, Mn, H; CEC, base saturation<br>Parameters to be optionally determined in the mineral layer 0 cm to10 cm: aqua regia total P, Ca, K, Mg, Mn; pH ($H_2O$)<br>Parameters to be determined in the mineral layer 10 cm to 20 cm (mandatory): pH ($CaCl_2$); organic C; total N; $CaCO_3$ (if pH $>$ 6); exchangeable acidity; BCE: Ca, Mg, K, Na; ACE: Al, $Fe^{3+}$, Mn, H; CEC, base saturation<br>Parameters to be optionally determined in the mineral layer 10 cm to 20 cm: aqua regia total P, Ca, K, Mg, Mn ; pH ($H_2O$)<br>Parameters to be determined in the mineral layer 20 cm to 40 cm (mandatory): pH ($CaCl_2$);<br>Parameters to be optionally determined in the mineral layer 20 cm to 40 cm: OC; Total N; $CaCO_3$ (if pH $>$ 6); aqua regia heavy metals Cu, Pb, Cd, Zn.<br>NOTE Several changes are in progress, in accordance with scientific panel discussions. |

| | |
|---|---|
| Soil archive | |
| Contact address | Dr. Davide De Laurentis<br>Mi.P.A.F. (Ministero delle Politiche Agricole e Forestali)<br>Direzione Generale delle Risorse Forestali, Montane ed Idriche<br>Corpo Forestale dello Stato<br>Divisione V<br>Via Carducci, 5<br>00187 Rome<br>Italy<br>Tel. 06 46656523/24<br>Fax 06 483498<br>e-mail: div05@corpoforestale.it, conecofor@corpoforestale.it<br>http://www.corpoforestale.it/conecofor/index.htm |

### A.2.4 Basal Soil Monitoring Scheme, BSMS (Czech Republic)

| | |
|---|---|
| Title | Basal Soil Monitoring Scheme (BSMS) |
| Level | National (Czech Republic) |
| Area of activity | Status and changes in soil properties, inputs of substances into the soil |
| Context | The system was established in 1992. It is divided into three subsystems, covering three distinct classes of land use and soil conditions:<br>— agricultural soil in standard conditions;<br>— polluted agricultural soil;<br>— protected areas.<br>There is also a connection to ICP monitoring on forest soil.<br>The BSMS is a part of legislation (Act No. 256/98 in the wording of later regulations) and two institutions are responsible for implementation: The Central Institute for Supervising and Testing in Agriculture, and the Agency for Nature and Landscape Conservation. |
| Monitoring objectives | — To provide data from a “reference” set of localities in order to characterize the status of soils;<br>— to observe changes in main soil characteristics, especially as a result of human activity;<br>— to test new field or analytical methods;<br>— to provide information from the field of soil science for research projects;<br>— by appropriate interpretation of results, to help to<br>  — develop methodologies to restrict degradation of landscape,<br>  — apply standards of sustainable development in agriculture,<br>  — develop strategies for soil protection and prevention. |
| Number of sites | — 190 on agricultural soil in standard conditions;<br>— 27 on polluted agricultural soil;<br>— 40 in protected areas. |
| Criteria for site selection | a) Agricultural subsystem in standard conditions, representing all soil types equally according to their area; proportional representation of arable land, grassland, vineyards, hop fields and orchards, taking into account climatic conditions and proportional location in a district area.<br>b) Agricultural subsystem in polluted areas, covering locations with contamination either from geogenic or anthropogenic sources on agricultural soil.<br>c) Subsystem in protected areas: undisturbed soils covering the main soil types and characteristics of vegetation (forests, meadows, marshes, peatland, alpine zones) in all protected areas of the country. |
| Sampling plan | Each individual plot is a rectangle covering an area of 1 000 $m^2$ (25 m $\times$ 40 m).<br>The basic sampling period is six years. Some parameters are analysed only at the beginning, some parameters are sampled and analysed every year.<br>Two horizons are sampled on arable soil, vineyards, hop fields and orchards, three horizons on grassland. In protected areas, sampling is carried out according to the diagnosed horizons.<br>Four mixed samples within each sampling layer are taken on the diagonals of the monitoring plot. These are bulked, each from ten individual samples.<br>At the beginning of the first period the soil pit is dug, samples from individual horizons are taken and the soil profile is described.<br>Each plot is located on a map and by geographical coordinates. |

| | |
|---|---|
| Field observations | — Recording of the identification information of a monitoring plot.<br>— Drawing a plan, measuring of GIS coordinates.<br>— Soil pit description. |
| Laboratory measurements | a) Parameters monitored once only, when defining the plot monitored:<br>— analyses of physical parameters (complete analyses of disturbed and undisturbed soil samples).<br>b) Parameters monitored over a six-year period:<br>— active reactions and exchange capacity of soil;<br>— content of available nutrients: P, K, Mg, Ca analysed by several methods;<br>— content of microelements (B, Mo, Mn, Zn, Cu, Fe);<br>— sorption capacity (S, T, V);<br>— organic matter content ($C_{ox}$);<br>— content of elements in nitric acid (As, Be, Cd, Co, Cr, Cu, Ni, Pb, V, Zn) and in aqua regia (Al, As, Be, Ca, Cd, Co, Cr, Cu, Fe, K, Mg, Mn, Mo, Ni, P, Pb, V, Zn) extractions, and total Hg content.<br>c) Parameters monitored yearly:<br>— content of mineral nitrogen;<br>— selected microbiological and biochemical parameters;<br>— content of selected organic pollutants (persistent organochloric pesticides, PCB, PAH).<br>d) Additional characteristics observed on selected monitoring plots:<br>— atmospheric deposition (bulk) for total N, nitrate-N, ammonium-N, sulfates, chlorides and elements: Ca, Mg, K, P, Na, Cu, Zn, Mn, Fe, Pb, Cd, Ni, and Cr; the atmospheric deposition is measured on a monthly cycle (this process is in operation in the agricultural and protected-area subsystems);<br>— contents of risk elements in plants on monitored plots in polluted areas and on a reference set of plots in agricultural subsystem in standard conditions. |
| Soil archive | Four mixed samples from each soil layer are stored every six years. Depth samples from selected localities are stored for later analyses of organic pollutants. |
| Contact address | Central Institute for Supervising and Testing in Agriculture<br>Hroznová 2<br>656 06 Brno<br>Czech Republic<br>e-mail: ukzuz@ukzuz.cz |

### A.2.5 Monitoring nutrient and heavy-metal concentrations in cultivated land (Finland)

| | |
|---|---|
| Title | Monitoring nutrient and heavy-metal concentrations in cultivated land |
| Level | National |
| Area of activity | Fields of the Agricultural Research Stations in Finland |
| Context | Regular soil testing every five years, based on fertilizer application on fields of research stations. Also micronutrients have been determined on a portion of the samples. The samples collected make it possible to follow the evolution of heavy metal pollution in plots cultivated normally. The recording of all treatments and crops cultivated allow the evaluation of factors causing changes. |
| Monitoring objectives | Monitoring the development of properties of cultivated soils in order to<br>— control environmental and health risks,<br>— be able to promote sustainable development,<br>— provide information to decision-makers for the basis of regulations,<br>— provide information to industry for new products or production methods to counteract unfavourable development,<br>— provide data for designing models to describe changes in the mineral elements in soil. |
| Number of sites | 153 in 1992; 122 in 1998. |
| Criteria for site selection | Of the stations having less than 50 ha cultivated area, five sites were sampled; of those larger than 50 ha, excepting the Jokioinen Estate, 20 samples were taken. |
| Sampling plan | Sampling area was 10 m × 10 m. Samples were collected from four corners of the area at the depth of a ploughed layer. Subsoil was also sampled to a depth of 40 cm. Subsamples were pooled. |
| Field observations | The location of the sampling site is recorded on a base map on a scale of 1:20 000 |
| Laboratory measurements | Analytical methods used are described in *Methods of Soil and Plant Analysis*, Agricultural Research Centre, 1986. Macronutrients are extracted with ammonium acetate (pH 4,65), and trace elements with the same extractant and additionally 0,02 mol/l EDTA.<br>B is extracted with boiling water. Determinations made include: pH, organic C, bulk density, electrical conductivity, Ca, K, Mg, P, Al, B, Cd, Co, Cr, Cu, Fe, Mn, Mo, Na, Ni, Pb and Zn |
| Soil archive | Samples are stored for possible later use. |
| Contact address | MTT<br>FIN-31600 Jokioinen<br>Finland<br>Tel. + 358 3 41 881<br>Fax + 358 3 4188 2222<br>e-mail: ritva.makela-kurtto@mtt.fi |

### A.2.6 Monitoring of cultivated Finnish soils (Finland)

| | |
|---|---|
| Title | Monitoring of cultivated Finnish soils |
| Level | National |
| Area of activity | Arable land |
| Context | The interest concerning the importance of minerals for the health of both people and animals resulted in 1974 in a research project on soil mineral elements, as their content in soil was recognized to be decisive for their concentrations in food and feedstuffs. Also since industrial growth was causing increased pollution, the need for monitoring the evolution of minerals in arable land was deemed important. |
| Monitoring objectives | Monitoring development of properties of cultivated soils in order to<br>— control environmental and health risks,<br>— promote sustainable development,<br>— provide information to decision-makers for the basis of regulations,<br>— provide information to industry for new products or production methods to counteract unfavourable development,<br>— provide data for designing models to describe changes in the mineral elements in soil. |
| Number of sites | 2015 in 1974; 1320 in 1987; 720 in 1998. |
| Criteria for site selection | In 1974, an indicator crop, timothy, was sampled in addition to soil. Therefore timothy fields representative of cultivated areas were selected. A random indicative sampling plan was followed. Sites closer than 400 m to railroads or busy highways, closer than 100 m to country roads, closer than 20 m to farm lanes or closer than 50 m to electric power lines were avoided.<br>A proportional reduction in the number of samples in 1987 and 1998 was made, so that the entire country was covered. |
| Sampling plan | The sampling area was 10 m × 10 m. Samples were collected from four corners of the area from a depth of 5 cm to 15 cm or from the middle of a ploughed layer. The subsamples were pooled. |
| Field observations | In 1974 a drawing of site was made to be able to locate it later. |
| Laboratory measurements | Analytical methods used are described in *Methods of Soil and Plant Analysis*, Agricultural Research Centre 1986. Macronutrients are extracted with ammonium acetate, pH 4,65 and trace elements with same extractant having 0,02 mol/l EDTA concentration additionally.<br>B and Se are extracted with boiling water. Determinations made include: pH, organic C, bulk density, electrical conductivity, Ca, K, Mg, P, Al, B, Cd, Co, Cr, Cu, Fe, Mn, Mo, Na, Ni, Pb, Se, Zn |
| Soil archive | Samples are stored for possible later use. |
| Contact address | MTT<br>FIN-31600 Jokioinen<br>Finland<br>Tel. + 358 3 41 881<br>Fax + 358 3 4188 2222<br>e-mail: ritva.makela-kurtto@mtt.fi |

### A.2.7 Integrated monitoring: tree stand and soil properties on permanent plots (Finland)

| | |
|---|---|
| Title | Integrated monitoring: tree stand and soil properties on permanent plots |
| Level | National contribution to a pan-European programme |
| Area of activity | Air pollution, especially of S, N and heavy metals |
| Context | Forest soil monitored as the soil chemistry (SC) subprogramme of Finland's contribution to the ICP Integrated Monitoring of Air Pollution Effects on Ecosystems (IM) programme under the UN-ECE Long-Range Transboundary Air Pollution. Monitoring, carried out at permanent monitoring plots established in forested catchments. IM sites are located in background areas (receiving only diffuse background pollution) and in unmanaged, old-growth forests (to minimize effects of forest management). National IM programme carried out in 4 forested catchments located between 61° N and 69° N. National SC monitoring programme started in 1988/89 and sampling has been repeated on two further occasions: 1991/92 and 1995/96. Monitoring of stand characteristics, including forest condition (defoliation and discoloration) carried out in the same stands as SC. Intensive monitoring of deposition (throughfall, stemflow), soil water, litterfall and litter decomposition also carried out on selected plots. |
| Monitoring objectives | The overall aim of the IM programme is to<br>— monitor and model the effects of long-range transported (diffuse) air pollution on the state of forest ecosystems in an integrated way,<br>— contribute to other aspects of relevance for forest policy at national and pan-European levels, such as effects of climate change on forests, mapping of critical loads, and biodiversity in forests.<br>Specific aims of the SC programme include<br>— characterization of soils, particularly in terms of soil chemical properties,<br>— monitoring changes in chemical properties of soil and substance pools indicating or related to the impacts of long-range transported (diffuse) air pollution,<br>— provision of data (parameters and variables) for the application of various biogeochemical models and critical load modelling (ICP on Modelling and Mapping). |
| Number of sites | 4 to 6 plots in each of 4 catchments. |
| Criteria for site selection | Catchments had to be<br>— hydrologically definable and geologically homogeneous,<br>— comprised of 10 ha to 1 000 ha and be surrounded by similar forest,<br>— no ongoing management,<br>— typical of the region,<br>— > 50 km from the nearest point-source of pollution.<br>Plots had to be<br>— located in the types of forest sites dominant in the catchment,<br>— as flat as possible,<br>— as homogeneous as possible with regard to soil morphology, ground vegetation and tree stand.<br>An attempt was also made to locate the plots on upper and lower slope segments within the same forest type. |

| | |
|---|---|
| Sampling plan | For the *SC* monitoring programme, humus layer (Of+Oh horizon), 0 cm to 5 cm, 5 cm to 20 cm and, where possible, also 20 cm to 40 cm as well as 60 cm to 80 cm mineral soil layers were sampled from each plot (typically measuring 40 m × 40 m). Samples were taken systematically from the entire plot such that there were 4 replicate samples of each layer, each consisting of soil taken from each 10 m × 10 m subplot. In addition, horizon and volumetric samples were taken from a soil pit to characterize the soil type and determine bulk density. |
| Field observations | Site and soil profiles are described from a pit dug adjacent to each plot. Soil is classified according to the FAO world soil classification. |
| Laboratory measurements | As far as possible, the procedures and methods outlined in the IM *Manual for Integrated Monitoring* (soil chemistry subprogramme) were followed. The samples were analysed for the complete set of mandatory *SC* properties: pH (measured in water and in 1 mol/l KCl), exchangeable titratable acidity (EA), exchangeable (extractable) base cations (Na, K, Ca and Mg), total organic carbon (TOC), loss-on-ignition (LOI), and total nitrogen. The following optional IM properties were also determined: exchangeable titratable aluminium acidity ($EA_{Al}$), total titratable acidity (TTA), total P and S, and "total" Mn, Pb, Cd, Cu and Zn. Effective and potential cation-exchange capacities ($CEC_e$, $CEC_p$) and related base saturations ($BS_e$, $BS_p$) were calculated. |
| Soil archive | Samples were stored in a sample bank. |
| Contact address | Finnish Forest Research Institute<br>Unioninkatu 40 A<br>00170 Helsinki<br>Finland<br>Tel. +358 10 2111<br>Fax +358 10 211 2101<br>Internet URL: http://www.metla.fi/<br>http://www.vyh.fi/eng/intcoop/projects/icp_im/im.htm<br>http://www.metla.fi/pp/MSta/index-en.htm<br>michael.starr@metla.fi |

### A.2.8 Monitoring of harmful substances in terrestrial environment (Finland)

| | |
|---|---|
| Title | Monitoring of harmful substances in terrestrial environment |
| Level | National, Finland |
| Area of activity | Air pollution, harmful and hazardous substances, background concentrations, food chains, Boreal forest ecosystem |
| Context | National programme for terrestrial monitoring of harmful substances in Finland started 1993, first with studies on indicator species, and followed the monitoring activities performed by the Finnish Environment Institute (SYKE). The species of interest are moose (*Alces alces*), the common shrew (*Sorex araneus*) and red wood ants (*Formica* sp.). Samples of the humus layer and precipitation are also collected and studied. The Boreal forest areas in use are highland areas which receive most of the harmful substances via air as long-range transported pollution (see UN LRTAP contract from 1979, AMAP, EMEP). The harmful substances are heavy metals and organo-chlorinated pesticides (OCPs) and PCB congeners. The use of these substances is banned or strongly regulated in EU countries. Often the sources of organic pollution are outside the EU boundaries, the substances are long-lived and of intermediate volatility, moving from warm to cold latitudes (North and South poles). |
| Monitoring objectives | The monitoring will provide data on levels of harmful substances in the "key species" of the Boreal forest ecosystems, which are moose (*Alces alces*), the common shrew (*Sorex araneus*) and red wood ants (*Formica* sp.). Also humus layer and precipitation are monitored.<br>The harmful substances are persistent organochlorinated pollutants and heavy metals. Their environmental concentrations are generally followed according to the international monitoring programmes.<br>The bio-samples are stored also into the environment specimen bank for retrospective chemical studies and development of analysing methods. |
| Number of sites | Four permanent sites, but every 5 years intensive sampling and monitoring on a total of eight sites. |
| Criteria for site selection | The monitoring sites are situated in the areas having other complementary monitoring activities such as EMEP, AMAP, ICP IM, ICP FOREST. The main criteria are the following:<br>— highland areas and Boreal spruce forest;<br>— minimum area of natural forest (100 ha to 500 ha) with buffer zones;<br>— availability for long-term monitoring;<br>— easy to access and carry out sampling;<br>— homogeneity of management operations within the site and the buffer zone. The monitoring areas should be as uniform as possible regarding animal species, soil type and forest type;<br>— diffuse pollution over the areas, no local sources. |
| Sampling plan | 3 to 5 years |
| Field observations | Observations are made on different management operations in the monitoring area, annual hunting statistics, weather, temperature, snow and water situation, "extraneous" appearance of dust in snow or precipitation. Rainwater, snow and humus layer are also collected for chemical analyses. |

| | |
|---|---|
| Laboratory measurements | Organochlorinated pesticides (OCPs): HCB, α-HCH, β-HCH, γ-HCH, α-chlordane, oxy-chlordane, *trans*-nonachlor, DDE, DDD and DDT, chlorophenols.<br>PCB-related compounds: congeners *n:r* 8, 18, 28, 31, 52, 66, 77, 101,105, 110, 118, 138, 149, 153, 156, 170, 180, and dioxines and furans.<br>Heavy metals: Al, Cr, Mn, Ni, Cu, Zn, Rb, Mo, Ag, Cd, Pt, Pb, Hg .<br>Screening of substances, including the EU Water Policy Directive: PAHs, nonylphenol, brominated flame retardants, phthalates, simazine, atrazine, trifluraline, organometallic compounds such as tributyl tin.<br>Fauna samples: tissue from liver, kidney, muscle, bone; age, body mass, liver mass (liver somatic index), body length, percent fat, dry mass.<br>Humus layer samples: humus/carbon content, mineral content, dry mass. |
| Soil archive | SYKE monitoring database/register |
| Contact address | Finnish Environment Institute<br>P.O.Box 140<br>FIN-00251 Helsinki<br>Finland<br>juha-pekka.hirvi@vyh.fi<br>http://www.vyh.fi/eng/welcome.html<br>http://esb.naturforvaltning.no |

### A.2.9 Permanent soil monitoring (Germany)

| | |
|---|---|
| Title | Permanent soil monitoring programme of the Federal Republic of Germany |
| Level | National/Federal States |
| Area of activity | Characterization of the soil status and its changes due to environmental impact |
| Context | Permanent soil monitoring emerged from initiatives of Federal States. The regulation for the installation of monitoring sites, compiled in 1990, standardized the programme at federal level. Installation and operation of the monitoring systems was accomplished by the Federal States. Evaluations on national level are based on data from Federal States, acquired by committees including federal and state authorities. |
| Monitoring objectives | The monitoring objectives are as follows:<br>— to characterize the soil status as a result of soil processes and environmental impacts;<br>— to determine and interpret changes in soil status;<br>— to identify requirements and possibilities of changes in environmental impacts on soil for a sustainable protection of the soil function;<br>— to estimate the transfer of hazardous compounds from soil to plant or to groundwater respectively, and the impact of airborne compounds on the soil (on selected plots only);<br>— to serve as a basis for scientific progress in the methodology of monitoring, as well as to understand the ecological background. |
| Number of sites | Approximately 800 |
| Criteria for site selection | The investigations are carried out at sites selected based on criteria of representativeness. |
| Sampling plan | Sampling for reinvestigations is carried out in an area of $> 1\,000\ m^2$. 18 sampling points are selected along diagonal lines. For resampling, the sampling points are shifted along the line or the patterns are rotated. Samples are collected from distinct soil horizons. Each composite sample consists of 6 randomly chosen samples. Linked to the area a soil profile is set up, primarily to characterize physical parameters of the soil horizons. At chosen points during the programme, stations are set up to monitor climate, soil water balance (water content, suction power), environmental conditions, and substances in soil solution. |
| Field observations | Vegetation and land-use effects are permanently registered (tillage, fertilization, fruit type, yield, forest maintenance). Measurements of airborne gases, macro- and micro-elements are taken from other monitoring programmes. |

| | |
|---|---|
| Laboratory measurements | The following parameters are analysed:<br>— soil chemical and soil physiochemical parameters (e.g. $C_{org}$, carbonate, pH, CEC);<br>— soil physical parameters (e.g. particle size distribution, substance density and bulk density, pore size distribution, suction power curve, saturated hydraulic conductivity);<br>— nutrient content (e.g. Ca, K, Na, Mg, base saturation);<br>— trace element content (e.g. by extraction with aqua regia);<br>— persistent organic pollutants (environmentally relevant groups);<br>— soil biological parameters;<br>— vegetation. |
| Soil archive | The analysed samples are archived for conservation of evidence and for further investigations. Some archived samples are cooled. |
| Contact address | Federal Institute for Geosciences and Natural Resources,<br>Stilleweg 2<br>30655 Hannover<br>Germany<br>http://www.bgr.de/<br><br>Federal Environmental Agency<br>Bismarckplatz 1<br>14193 Berlin<br>Germany<br>http://www.umweltbundesamt.de/ |

### A.2.10 National soil monitoring network (the Netherlands)

| | |
|---|---|
| Title | National Soil Monitoring Network |
| Level | Country |
| Area of activity | Soil pollution, groundwater pollution |
| Context | In the Netherlands, a national soil quality monitoring network has been operational since 1993. Every 6 years, the same locations are sampled to detect long-term changes in soil quality on a national scale. Together with the data on soil quality, information is collected on mineral and heavy metal balances at the selected locations, in order to explain possible trends observed concerning soil quality. |
| Monitoring objectives | To determine the changes in soil quality in the Netherlands over time and (in the case of heavy metals) to explain these changes using quantitative information on input and output of heavy metals. |
| Number of sites | 200 |
| Criteria for site selection | Representativeness for a major land-use type or a major soil type in the Netherlands.<br>The sites are subject only to diffuse pollution (not to local pollution).<br>For agricultural sites: knowledge of farming practices and mineral balances |
| Sampling plan | The monitoring network consists of 10 categories. Each category has 20 sampling locations (i.e. farms). Each year two categories, with 40 locations in total, are sampled. Each category is sampled every six years.<br>Samples are taken from the topsoil (0 cm to 10 cm depth), the subsoil (30 cm to 50 cm) and the uppermost groundwater (the top 1 m of this layer).<br>The average concentration for a location is estimated as follows: At each location (farm), 320 soil samples are taken from the topsoil, evenly distributed over all fields belonging to the farm. These 320 samples are randomly divided over 4 buckets (composite samples); each bucket thus contains 80 soil samples. The soil in one bucket is mixed thoroughly in the field, after which one sample (about 1 kg of soil) per bucket is taken to the laboratory and analysed using standard soil analysis methods. The results of the four sub-samples are averaged into one value for a particular location. |
| Field observations | Soil profile description |
| Laboratory measurements | The main substances analysed in the solid phase of the soil are heavy metals, polycyclic aromatic hydrocarbons (PAH) and pesticides. At the first visit to a location standard soil physical (e.g. texture) and chemical properties (e.g. carbon content, CEC) are also determined.<br>In the groundwater, the major compounds analysed are heavy metals and nutrients. |
| Soil archive | All soil samples are stored in a soil bank. |
| Contact address | http://www.rivm.nl<br>hans.bronswijk@rivm.nl |

### A.2.11 National network for long-term monitoring of forest ecosystems RENECOFOR (France)

| | |
|---|---|
| Title | National network for long-term monitoring of forest ecosystems (RENECOFOR) |
| Level | National |
| Area of activity | Detection of and explanation for possible changes in the functioning of ecosystems, soil being a constituent of the ecosystem. |
| Context | The RENECOFOR network was set up by the ONF (Office National des Forêts) in 1992 in order to supplement the system monitoring the health of French forests. It constitutes the French part of a series of permanent subplots for monitoring forest ecosystems installed in 34 European countries. |
| Monitoring objectives | The monitoring objectives concern forest ecosystems in the wide sense of the term (tree planting, evolution, distribution, parasitology, etc.). Soil studies constitute an additional parameter to be measured, in order to assess its importance in the development of the ecosystem.<br>Concerning soil in particular, this involves better defining the changes over time in the physico-chemical properties related to various environmental factors (human-induced or not). |
| Number of sites | The network is made up of 102 permanent subplots which will be monitored over at least 30 years. Each subplot has a surface area of 2 ha, the central 0,5 ha area of which is fenced off. |
| Criteria for site selection | These ecosystems were selected to be representative of the region in which they are located: the subplots correspond to plantations that are representative of the production forests and of the forestry treatments of the different regions of France. These plantations are located in average conditions regarding both altitude and the type of station. The principal French species selected are common oak (*Quercus pedunculata*) and sessile oak, beech, spruce, Douglas fir, larch, laricio pine, maritime pine, Scotch pine (*Pinus silvestris*), and fir. |
| Sampling plan | Sampling operations were carried out in five 13,5 m $\times$ 13,5 m square clusters, arranged in the 4 corners of the subplot and in its centre. Within each cluster, 5 sampling points were randomly selected among the 16 intersections defined by a 4,5 m square grid. At each point, samples were taken from 4 to 5 levels : OL+OF+OH (if OH $<$ 1 cm) or OL+OF and OH (if OH $\geqslant$ 1 cm), 0 cm to 10 cm, 10 cm to 20 cm and 20 cm to 40 cm. For each sampling level, a composite sample for analysis was made up by grouping together, in equal volumes, 5 samplings from the cluster. In the central cluster, a fraction of each of the 5 samplings was also stored separately for subsequent analyses. |
| Field observations | Morphological descriptions of the profiles were also conducted between 1994 and 1995 on two pedological pits per subplot. Attention is paid to the description of the forms of humus due to their characteristic interface between the climate, the vegetation (in the wide sense of the term) and the soil. A description manual was developed for this operation. In each cluster, the mass of dead matter per unit area (holorganic horizons, using the frame method) and the apparent densities of the fine earth (mineral layers, generally the cylinder method) are assessed on a composite of 5 samplings.<br>The results of the descriptions are presented, subplot by subplot, in a series of four categories:<br>— general geological, topographical and humus-content characteristics, general comment on these soils;<br>— detailed descriptions of each of the pits;<br>— description of the forms of humus;<br>— results of the physico-chemical analyses carried out on one of the two pits and averages of those conducted on the clusters (see following section). |

| | |
|---|---|
| Laboratory measurements | — In the holorganic horizons, organic carbon, total nitrogen and total alkaline cations (Ca, Mg, K) are analysed. In the case of independent sampling of horizon OH, the following additional analyses were carried out in the latter: total heavy metals (Cd, Cu, Ni, Pb, Zn), exchangeable cations (Ca, Mg, K, Al, Mn, H), pH ($H_2O$ and $CaCl_2$), total, extractable phosphorus, and carbonates (if pH $CaCl_2 > 6$).<br>— The mineral layers were analysed for organic carbon, total nitrogen (0 cm to 10 cm) or Kjeldahl nitrogen (10 cm to 20 cm and 20 cm to 40 cm), extractable phosphorus, pH ($H_2O$ and $CaCl_2$), carbonates (if pH of $CaCl_2 > 6$) and exchangeable cations (Ca, Mg, K, Al, Mn, H).<br>— Additional samples are taken from five characteristic pedogenetic horizons (or less, for shallow soils). Three of them formed the subject of a particle size (granulometric) analysis, of the determination of free iron and aluminium, and of the measurement of the pH of $H_20$ |
| Soil archives | The soils are stored in semi-opaque polyethylene containers inside a roofed building, without temperature and humidity control. |
| Contact address | ONF DTRD RENECOFOR<br><br>Boulevard de Constance<br>77 300 Fontainebleau<br>France<br>Tel. 01 60 74 92 21<br>Fax: 01 64 22 49 73<br>http://www.onf.fr/pro/renecofor/index.HTM<br>E-mail: erwin.ulrich@onf.fr |

### A.2.12 Soil Quality Measurement Network (France)

| | |
|---|---|
| Title | Soil Quality Measurement Network (RMQS) |
| Level | National |
| Area of activity | Condition and change in soil properties |
| Context | The Soil Quality Measurement Network is an operation piloted by the GIS SOL (Groupement d'Intérêt Scientifique Sol), which groups together members of the Ministry for Agriculture and Fisheries, the Ministry for Regional Development and the Environment, the National Institute for Agronomical Research (INRA), the French Environment Institute (IFEN) and the Agency for the Environment and Energy Management (ADEME). Responsibility for the coordination, setting up and monitoring of the RMQS was entrusted by the GIS Sol to the Infosol Unit in Orléans, which is a service unit combining INRA and IFEN. |
| Monitoring objectives | The functions of RMQS are the following:<br>— alerting (early detection of unsuspected changes);<br>— national assessment (overall statistical vision of the change in soil characteristics);<br>— mapping (allowing an "instantaneous photograph" of the quality of soils, detection of gradients);<br>— validation of geographical predictions (established on the basis of evolution models, calibrated on research sites and applied on georeferenced databases, stemming from inventory programmes);<br>— conservation. |
| Number of sites | 2 100 sites uniformly distributed over the French territory, according to a 16 km square grid, modelled on the European network of monitoring forest damage (ICP-Forests, level I). Measurement and observations will be carried out every five years at the centre of each grid. This alerting network will be supplemented by the setting up of a network of "benchmark sites", devoted to understanding the changes in soil properties and to improving the interpretation of the alert network data. |
| Criteria for site selection | Each monitoring site shall be located as close as possible to the theoretical coordinates, while complying with the following constraints:<br>— possessing a natural or cultivated soil (exclude urbanized zones or zones which have been highly modified by man, for instance concreted, tarred areas, embankments and backfill, sites on reconstituted soils, industrial sites, rubbish dumps, former quarries, home gardens, leisure activity sites, etc.).<br>— having the authorization of the farmer or owner for conducting the sampling operations, and having the response to the questionnaire concerning the background history of the site and its uses.<br>— presenting a surface area of at least 900 $m^2$, which is homogeneous from the point of view of topography, background history, land use and management practices, soil type, and aspect of soil surface.<br>Account being taken of these constraints, a tolerance of 1 km around the theoretical point is accepted for the selection of the site |

| | |
|---|---|
| Sampling plan | The sampling zone of each site comprises three components: a soil examination, a pedological pit and a sampling surface. The soil examination and the pedological pit are used for describing the soil. The 20 m × 20 m square sampling surface is delimited at the centre of the sampling zone, at approximately 5 m to the north of the pedological pit. This surface is divided up into 100 sampling units of 4 $m^2$ each (2 m × 2 m). During each survey, two composite samples are taken from the surface (0 cm to 30 cm) and subsurface (30 cm to 50 cm) layer. In the presence of a surface organic horizon (horizon O), a composite sample is also taken. These composite samples stem from a mixture of 25 individual samplings evenly spread out over the sampling surface. Samples are also taken from each horizon in the pedological pit. |
| Field observations | The environment of the site, the uncultivated soil vegetation and the soil profile are described for each site. A survey concerning the background history, the land use and the management practices is conducted on each site. |
| Laboratory measurements | The apparent density of the soil and the percentage of coarse elements are determined for each site. The composite samples form the subject of the following analyses:<br>— granulometric analysis (NF X31-107);<br>— pH of water (ISO 10390);<br>— total limestone (if pH of water > 6,5; ISO 10693);<br>— carbon and total nitrogen (ISO 10694 and ISO 13878);<br>— $P_2O_5$ (Olsen);<br>— CEC (cobaltihexamine);<br>— exchangeable cations (Ca, K, Mg, Na, Mn, Al, Fe, cobaltihexamine);<br>— water-soluble boron (NF X31-122);<br>— total major elements (Na, Ca, Mg, K, Fe, Mn, Al);<br>— total trace elements (Cd, Co, Cr, Cu, Ni, Pb, Tl, Zn) (NF X31-121) and unbuffered EDTA extracts (Cd, Cr, Cu, Ni, Pb, Zn). |
| Soil archives | All samples are stored in a sample bank. |
| Contact address | INRA - Unité Infosol<br>Avenue de la Pomme de Pin<br>BP 20619 Ardon<br>F-45166 Olivet Cedex<br>e-mail: infosol@orleans.inra.fr |

### A.2.13 National survey of forest soil and vegetation (Sweden)

| | |
|---|---|
| Title | National survey of forest soil and vegetation |
| Level | National |
| Area of activity | Forested land, peatlands and permanent grazing land |
| Context | The survey is part of the Swedish national environmental monitoring programmme, financed through the Swedish Environmental Protection Agency. It is performed by the Department of Forest Soils, Swedish University of Agricultural Sciences (SLU). Material collected from 1961 onwards, but the first inventory on the permanent plots of the National Forest Inventory was made 1983-1987. The second inventory started 1993 and finished 2002. A third inventory started in 2003. Part of the Swedish commitment to the Level I inventory within ICP Forest. The fieldwork and database of the inventory is integrated with the National Forest Inventory, also performed by SLU. |
| Monitoring objectives | To create a national database for studies of status and trends in soils and vegetation by repetitive surveys of the permanant plots of the National Forest Survey using an objective statistical design. The database should have a resolution that permits area based analysis of data on regional and national level. The data are intended to<br>— provide a basis for decisions on the land-use and soil conservation measures of Swedish forest land,<br>— be used for monitoring changes in the soils caused by changes in the environment,<br>— be used for studies on the interaction between soils and tree growth,<br>— provide material for research on soils and vegetation in Swedish forests. |
| Number of sites | 24 000 |
| Criteria for site selection | Sites chosen objectively, in clusters of 4 or 8 plots. The clusters (tracts) form an equilateral grid over the entire country. |
| Sampling plan | 1/10 of the plots are inventoried every year. |
| Field observations | Site characteristics (moisture regime, stoniness, hydrology, soil depth, cultural influence).<br>Soil characteristics for 3 to 4 horizons (humus form, soil type, texture, parent material).<br>Soil sampling (according to soil type).<br>Plant species from tree, bush, field and bottomlayer (267 species present, 70 species covered).<br>Algae on Norway spruce needles (presence, coverage).<br>Pendulous lichens — three species (presence, length). |
| Laboratory measurements | pH ($H_2O$, 0,01 mol/l $CaCl_2$, 1 mol/l KCl)<br>C, N (dry combustion)<br>Extractable cations ($Ca^{2+}$, $Mg^{2+}$, $K^+$, $Na^+$, $Mn^{2+}$), 1 mol/l ammonium acetate extraction<br>Exchangeable acidity (1 mol/l ammonium acetate)<br>Exchangeable Al (1 mol/l KCl) |
| Soil archive | Yes. Contains more than 100 000 stored samples. |
| Contact address | Lars Lundin<br>Department of Forest Soils, SLU<br>Box 7001<br>S-750 07 Uppsala<br>Sweden<br>Tel. +46 18 67 10 70 |

### A.2.14 ICP-forest

| | |
|---|---|
| Title | ICP-forests |
| Level | Europe |
| Area of activity | Air pollution |
| Context | The International Cooperative Programme on the Assessment and Monitoring of Air Pollution on Forests began in 1985. It is an integral part of the Cooperative Programme for Monitoring and Evaluation of the long-range transmission of Air Pollutants in Europe (EMEP) of the Long-Range Transboundary Air Pollution (LRTAP) convention of the United Nations. A programme for intensive and continuous monitoring was implemented based on an extensive systematic network (16 km $\times$16 km grid) (ICP Forests, Level I). This large-scale survey was extended by the establishment of more intensively monitored plots (ICP Forests, Level II) which included crown condition assessment, soil and foliar surveys, growth/yield increment studies, deposition measurements and meteorological observations |
| Monitoring objectives | The objectives are the following:<br>— to provide a periodic overview on the spatial and temporal variation in forest condition in relation to anthropogenic (in particular air pollution) as well as natural stress factors on a European and national large-scale systematic network (Level I);<br>— to contribute to a better understanding of the relationships between the condition of forest ecosystems and anthropogenic (in particular air pollution) as well as natural stress factors through intensive monitoring on a number of selected permanent observation plots spread over Europe (Level II) and to study the development of important forest ecosystems in Europe;<br>— to provide a deeper insight into the interactions between the various components of forest ecosystems by compiling available information from related studies;<br>— to contribute, in close cooperation with the ICP on Modelling and Mapping, to the calculation of critical levels/loads and their surpassing in forests, and to improve collaboration with other environmental monitoring programmes inside and outside the CLRTAP;<br>— to contribute, by means of the monitoring activities, to other aspects of relevance for forest policy at national, pan-European and global levels, such as effects of climate changes on forests, sustainable forest management and biodiversity in forests;<br>— to provide policy-makers and the general public with relevant information. |
| Number of sites | Approximately 440 observation plots in the European Union, and substantial numbers of plots in countries adjacent to the EU-15. |

| | |
|---|---|
| Criteria for site selection | The selection of the plots is the responsibility of the participating countries, but the following main criteria apply:<br>— representativeness of forest species and growing conditions for the country;<br>— minimum area (0,25 ha);<br>— minimization of external effects (buffer zone);<br>— availability for long-term monitoring;<br>— ease of access and sampling;<br>— homogeneity of management operations within the plot and the buffer zone;<br>Pollution from known local sources should be avoided.<br>A sufficient number of trees should be available for sampling.<br>The plots and buffer zone should be as uniform as possible regarding species or species mixture, age, size, soil, and slope.<br>The plots should be located so as to avoid forest edge effects. |
| Sampling plan | Soil samples are collected within the plot by fixed depth or by horizon. Where sampling is made by fixed depth, the following layers are used: 0 cm to 10 cm (or 0 cm to 5 cm and 5 cm to 10 cm separately); 10 cm to 20 cm; 20 cm to 40 cm; 40 cm to 80 cm<br>In order that samples be statistically representative for each plot, for every layer or horizon sampled, several individual samples or at least one representative composite sample should be collected. In practice, these global recommendations have resulted in various sampling designs, both within and between countries. |
| Field observations | The soils in each plot are characterized, with the profile description made in the buffer zone according to the FAO system. It is recommended that the dry bulk density be determined from undisturbed soil, so as to enable all data to be converted to a common mass-basis. |
| Laboratory measurements | The document *Manual on methodologies of forest soil sampling and analysis* gives approved analytical methods and advises that they be used. It also distinguishes between mandatory and optional parameters. If these methods are not used, the comparability of the analysis results should be reported in detail, together with results. The determination of soil particle-size distribution is mandatory.<br>Mandatory and optional parameters: exchangeable acid cations (ACE), aluminium (Al), base cations exchangeable (BCE), base saturation (BaseSat), cadmium (Cd), calcium (Ca), calcium carbonate($CaCO_3$), cation exchange capacity (CEC), chromium (Cr), copper (Cu), electrical conductivity (EC), exchangeable acidity (Ac-Exc), iron (Fe), lead (Pb), magnesium (Mg), manganese (Mn), mercury (Hg), nickel (Ni), nitrogen (N), organic carbon (C-org), organic layer (OrgLay), pH ($CaCl_2$), pH ($H_2O$), phosphorus (P), potassium (K), sodium (Na), sulfur (S), zinc (Zn) |
| Soil archive | It is advised that part of the sample be stored in a soil bank for comparison with future samples. |
| Contact address | Web page: http://www.icp-forests.org |

# Bibliography


[1] BARTH, N., BRANDTNER, W., CORDSEN, F., DAM, T., EMMERICH, K.H., FELDHAUS, D., KLEEFISCH, B., SCHILLING, B. and UTERMANN, J. *Boden-Dauerbeobachtung: Einrichtung und Betrieb von Boden-Dauerbeobachtungsflächen* (2000). Rosenkranz/Einsele/Harress (Hrsg.). BoS 32. Lfg. XI/2000 Kap. 9152

[2] GILBERT, R.O. *Statistical methods for environmental pollution monitoring*, Van Nostrand Reinhold, cop1987, 320 p

[3] LINDER, G., INGHAM, E., BRANDT, C.F. and HENDERSON, G. *Ecological Techniques for the Assessment of Terrestrial Superfund Sites* (1992). PB93-100865, EPA/600/02, USA

[4] *Manual for Integrated Monitoring* (1998). International Cooperative Programme on Integrated Monitoring of Air Pollution Effects on Ecosystems, ICP IM Programme Centre, Finnish Environment Institute, P.O. Box 140, FIN-00251 Helsinki, Finland

[5] *Manual on methods and criteria for harmonized sampling, assessment, monitoring and analysis of the effects of air pollution on forests*, 4th edition (1998). Programme Coordinating Centre, Federal Research Centre for Forestry and Forest Products (BFH), Hamburg, Germany

[6] MEIJERS, E.M.J. Defining Confusions — Confusing Definitions, *Environmental Monitoring and Assessment*, **7** (1986), pp. 157-59

[7] SCHULIN, R., DESAULES, A., WEBSTER, R. and VON STEIGER, B. *Soil Monitoring. Early Detection and Surveying of Soil Contamination and Degradation* (1993), Birkhäuser Verlag, Basle, Switzerland

[8] TORSTENSSON, L. *Guidelines. Soil Biological Variables in Environmental Hazard Assessment* (1993), Uppsala University, Sweden

[9] WEBSTER, R. and OLIVER, M.A. *Statistical Methods in Soil and Land Resource Survey* (1990). Oxford University Press

[10] ISO 3534-1, *Statistics — Vocabulary and symbols — Part 1: Probability and general statistical terms*

[11] ISO 10381-1, *Soil quality — Sampling — Part 1: Guidance on the design of sampling programmes*

[12] ISO 10381-2, *Soil quality — Sampling — Part 2: Guidance on sampling techniques*

[13] ISO 10381-3, *Soil quality — Sampling — Part 3: Guidance on safety*

[14] ISO 10381-4, *Soil quality — Sampling — Part 4: Guidance on the procedure for the investigation of natural, near natural and cultivated sites*

[15] ISO 10390, *Soil quality — Determination of pH*

[16] ISO 10693, *Soil quality — Determination of carbonate content — Volumetric method*

[17] ISO 10694, *Soil quality — Determination of organic and total carbon after dry combustion (elementary analysis)*

[18] ISO 11074-1, *Soil quality — Vocabulary — Part 1: Terms and definitions relating to the protection and pollution of the soil*

[19] ISO 11074-2, *Soil quality — Vocabulary — Part 2: Terms and definitions relating to sampling*

[20] ISO 11259, *Soil quality — Simplified soil description*

[21] ISO 11260:1994, *Soil quality — Determination of effective cation exchange capacity and base saturation level using barium chloride solution*

[22] ISO 11260:1994/Cor. 1:1996, *Technical corrigendum 1*

[23] ISO 11265, *Soil quality — Determination of the specific electrical conductivity*

[24] ISO 11272, *Soil quality — Determination of dry bulk density*

[25] ISO 11277, *Soil quality — Determination of particle size distribution in mineral soil material — Method by sieving and sedimentation*

[26] ISO 11465:1993, *Soil quality — Determination of dry matter and water content on a mass basis — Gravimetric method*

[27] ISO 11465:1993/Cor. 1:1994, *Technical corrigendum 1*

[28] ISO 13536, *Soil quality — Determination of the potential cation exchange capacity and exchangeable cations using barium chloride solution buffered at pH=8,1*

[29] ISO 13878, *Soil quality — Determination of total nitrogen content by dry combustion ("elemental analysis")*

[30] ISO 14235, *Soil quality — Determination of organic carbon by sulfochromic oxidation*

[31] ISO 15903, *Soil quality — Format for recording soil and site information*

[32] ISO/IEC 17025, *General requirements for the competence of testing and calibration laboratories*

[33] NF X31-107, *Qualité du sol — Détermination de la distribution granulométrique des particules du sol — Méthode à la pipette*

[34] NF X31-121, *Qualité des sols — Méthodes chimiques — Détermination du cuivre, du manganèse, du zinc et du fer — Extraction en présence de DTPA*

[35] NF X31-122, *Qualité des sols —Extraction et dosage du bore soluble à l'eau bouillante*

**ICS 13.080.01**

Price based on 34 pages